

Improved Hospital Morbidity, Mortality, and Survival after the Whipple Procedure

DAVID W. CRIST, M.D., JAMES V. SITZMANN, M.D., and JOHN L. CAMERON, M.D., F.A.C.S.

Between 1969 and 1986, 88 patients had a Whipple resection for adenocarcinoma of the pancreas (N = 50), ampulla (N = 19), distal bile duct (N = 10), and duodenum (N = 9). Forty-nine patients were men, 39 were women, and the mean age was 58 years (range: 34–84 years). The patients were divided into two groups on the basis of two different time periods: those operated on from 1969 to 1980 (N = 41) and those operated on from 1981 to 1986 (N = 47). There were no significant differences between the two groups in terms of mean age, sex distribution, duration of symptoms before presentation, or mean weight loss. Likewise, preoperative laboratory data were similar for both groups of patients. In addition, mean tumor size for patients with pancreatic cancer (3.5 cm vs. 3.2 cm) and patients with nonpancreatic periampullary cancer (1.9 cm vs. 2.2 cm) was similar in both groups, as was the incidence of positive lymph nodes. Among the 41 patients operated on during the first period, hospital morbidity and mortality rates were 59% and 24%, respectively. In contrast, hospital morbidity and mortality rates were 36% and 2%, respectively, among the 47 patients operated on during the recent period. During the recent period, more Whipple procedures were performed each year (7.8 vs. 3.4) and by fewer surgeons (3.4 operations/surgeon vs. 1.9 operations/surgeon). In addition, between 1981 and 1986, there were fewer total pancreatectomies (9% vs. 39%), fewer vagotomies (26% vs. 76%), and more pyloric-preserving procedures (30% vs. 0) performed compared with the earlier period. During the recent period, mean operative time (7.8 vs. 9.0 hours), mean estimated blood loss (1694 vs. 3271 mL), and mean intraoperative blood replacement (3.6 vs. 6.3 units) were all significantly less than in the earlier period. These findings suggest that the recent decline in operative morbidity and mortality may be due to fewer surgeons performing more Whipple resections in less time and with less blood loss. The actuarial 5-year survival rate for the 38 patients with nonpancreatic periampullary cancer was 34%. Surprisingly, the actuarial 5-year survival rate among the 50 patients with pancreatic cancer was 18%. Moreover, in the absence of positive lymph node involvement, the 5-year actuarial

From the Department of Surgery, The Johns Hopkins Medical Institutions, Baltimore, Maryland

survival rate among patients with pancreatic cancer was 48%. No explanation is obvious for the improvement in survival among patients with pancreatic cancer.

THE FIRST SUCCESSFUL RESECTION of a periampullary carcinoma in the United States was performed by Halsted in 1898.¹ The tumor was merely excised locally, and the patient died 7 months later of tumor recurrence. Whipple and colleagues,² in 1935, described the first pancreaticoduodenectomy performed for a periampullary carcinoma. The procedure was performed in two stages. The operation subsequently underwent modifications, and was first reported as a one-stage procedure by Trimble and Associates³ in 1941. Thereafter, the pancreaticoduodenectomy became the operation of choice for patients with cancer of the head of the pancreas, ampulla, distal bile duct, and duodenum. However, during the 1960s and 1970s, some suggested that the Whipple procedure should be abandoned for the management of pancreatic cancer because of a high operative mortality rate, and virtually no long-term survivors.^{4–6} Recently, several reports have suggested a sharp decrease in morbidity and mortality for the Whipple procedure,^{7–9} as well as significantly improved survival for all periampullary tumors, including adenocarcinoma of the pancreas.^{9,10} We have reviewed the experience with the Whipple procedure over an 18-year period at the Johns Hopkins Hospital to determine whether similar trends were evident in our patients.

Clinical Material

Between January 1969 and May 1986, 108 patients had an elective Whipple resection at the Johns Hopkins Hospital. Periampullary carcinoma was the indication

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Reprint requests and correspondence: John L. Cameron, M.D., Department of Surgery, The Johns Hopkins Medical Institutions, Baltimore, MD 21205.

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TABLE 1. Patients Undergoing Pancreaticoduodenectomy for Periapillary Carcinoma*

	1969–1986 (N = 88)	1969–1980 (N = 41)	1981–1986 (N = 47)	p
Operative indication				
Pancreatic cancer	50 (57)	26 (63)	24 (51)	NS
Ampullary cancer	19 (22)	7 (17)	12 (26)	NS
Bile duct cancer	10 (11)	4 (10)	6 (13)	NS
Duodenal cancer	9 (10)	4 (10)	5 (11)	NS
Mean age	58.4 ± 1.1	59.1 ± 1.5	57.8 ± 1.6	NS
Sex				
Male	49 (56)	24 (59)	25 (53)	NS
Female	39 (44)	17 (41)	22 (47)	NS
Race				
Black	20 (23)	11 (27)	9 (19)	NS
White	68 (77)	30 (73)	38 (81)	NS
Symptoms				
Jaundice	72 (82)	35 (85)	37 (79)	NS
Weight loss	66 (75)	32 (78)	34 (72)	NS
Mean weight loss (lbs)	14.4 ± 1.6	16.1 ± 2.1	12.1 ± 2.0	NS†
Abdominal pain	46 (52)	20 (49)	26 (55)	NS
Mean duration of symptoms (weeks)	8.1 ± 1.2	8.2 ± 1.5	7.8 ± 1.9	NS
Physical findings				
Hepatomegaly	28 (32)	18 (44)	10 (21)	<0.05
Palpable gallbladder	20 (23)	11 (27)	9 (19)	NS
Occult fecal blood	24 (27)	9 (22)	15 (32)	NS
Palpable abdominal mass	3 (3)	1 (2)	2 (4)	NS
Medical illnesses				
Diabetes mellitus	15 (17)	8 (20)	7 (15)	NS
Coronary artery disease	8 (9)	4 (10)	4 (9)	NS
Obstructive lung disease	6 (7)	3 (7)	3 (6)	NS
History of smoking	46 (52)	24 (59)	22 (47)	NS
Previous exploration	15 (17)	7 (17)	8 (17)	NS
Laboratory data				
Hematocrit (%)	37.1 ± 0.54	37.5 ± 0.71	36.8 ± 0.80	NS
WBC (10 ⁶ /mm ³)	8.1 ± 0.37	7.7 ± 0.59	8.4 ± 0.46	NS
Total lymphocyte count	1854 ± 163	1786 ± 192	1941 ± 236	NS
Bilirubin (mg/dL)	9.4 ± 0.75	10.1 ± 1.11	9.0 ± 0.97	NS
Alkaline Phosphatase (IU/L)	510 ± 40.8	612 ± 68.7	425 ± 44.3	<0.05†
SGOT	163 ± 13.8	182 ± 22.3	146 ± 16.9	NS†
Albumin (g/dL)	3.7 ± 0.06	3.7 ± 0.10	3.8 ± 0.07	NS
Prothrombin time (secs)	12.4 ± 0.12	12.8 ± 0.21	12.1 ± 0.13	NS
Creatinine (mg/dL)	1.04 ± 0.3	1.05 ± 0.3	1.04 ± 0.4	NS

* Numbers in parentheses represent percentages.

† Wilcoxon nonpaired rank sum test.

for surgery in 88 of the 108 patients. Of these 88 patients, there were 50 with adenocarcinoma of the head of the pancreas, 19 with adenocarcinoma of the ampulla, 10 with adenocarcinoma of the distal bile duct, and nine with adenocarcinoma of the duodenum. The remaining 20 patients had pancreaticoduodenectomy for a variety of other benign and malignant diseases, and were excluded from this review.

Of the 88 patients with periampullary tumors, 49 were men and 39 were women (Table 1). Sixty-eight patients (77%) were white and 20 (23%) were black. The patients ranged in age from 34 to 84 years with a mean age of 58.4 years. Jaundice was the most common presenting symptom and was present in 72 patients (82%). Weight loss occurred in 66 patients (75%). Mean weight loss for these 66 patients was 14.4 ± 1.6 pounds. Abdominal pain was present in 46 patients (52%). The mean duration of symptoms before hospitalization was

8.1 ± 1.2 weeks. Physical findings included hepatomegaly in 28 patients (32%), a palpable gallbladder in 20 patients (23%), and a palpable abdominal mass in three patients (3%). A previous history of adult onset diabetes of at least 2 years' duration was present in 13 patients (15%). Two additional patients (2%) had new onset diabetes mellitus. Eight patients (9%) had a history of significant coronary artery disease and six patients (7%) had chronic obstructive pulmonary disease. Fifteen patients (17%) had had a recent laparotomy before referral to this hospital. Mean laboratory data (Table 1) on admission to the Johns Hopkins Hospital included a hematocrit of 37%, white blood cell count of 8100, total lymphocyte count of 1854, a bilirubin level of 9.4 mg/dL, alkaline phosphatase level of 510 IU/L, SGOT of 163 IU/L, serum albumin level of 3.7 g/dL, prothrombin time of 12.4 seconds, and serum creatinine level of 1.04 mg/dL.

In an effort to detect recent trends in operative mor-

TABLE 2. Operative Data for Patients Undergoing Pancreaticoduodenectomy*

	1969-1986 (N = 88)	1969-1980 (N = 41)	1981-1986 (N = 47)	p
Operation performed				
Total pancreatectomy	20 (23)	16 (39)	4 (9)	<0.01
Partial pancreatectomy	68 (77)	25 (61)	43 (91)	<0.01
Pyloric-sparing Whipple	14 (16)	0 (0)	14 (30)	<0.01
Partial gastrectomy	74 (84)	41 (100)	33 (70)	<0.01
Concomitant vagotomy	43 (49)	31 (76)	12 (26)	<0.01
No vagotomy	45 (51)	10 (24)	35 (74)	<0.01
Operative data				
Operative time (hours)	8.4 ± 0.24	9.0 ± 0.34	7.8 ± 0.31	<0.05†
Estimated blood loss (mL)	2519 ± 263	3271 ± 440	1694 ± 281	<0.01†
Intraoperative blood transfusion (mL)	4.9 ± 0.39	6.3 ± 0.65	3.6 ± 0.37	<0.01†
Whipple resections per year		3.4	7.8	
Whipple resections per surgeon		1.9	3.6	

* Numbers in parentheses represent percentages.

† Wilcoxon nonpaired rank sum test.

bidity and mortality, the patients were divided into two groups on the basis of two time periods: those operated on between 1969 and 1980, and those operated on between 1981 and 1986. Forty-one patients were operated on during the first period, and 47 patients had a Whipple resection during the recent period.

Comparison of the two groups revealed no significant difference in terms of mean age, sex distribution, race, presenting symptoms, duration of symptoms, physical findings, or associated medical illnesses. Moreover, all preoperative laboratory data were similar in both groups of patients (Table 1).

Operative Management

Among the 88 patients, 68 (77%) had a Whipple operation that included resection of the head, neck, and uncinate process of the pancreas (Table 2). The remaining 20 patients (23%) had a Whipple operation that included a total pancreatectomy. Of the 20 patients managed by total pancreatectomy, 16 had carcinoma of the pancreas, two had carcinoma of the distal bile duct, one had carcinoma of the ampulla, and one patient had duodenal carcinoma. A pyloric-preserving Whipple procedure was used in 14 of 88 patients (16%). A truncal vagotomy was performed in 43 of 88 patients (49%).

The management of the pancreatic remnant varied according to the preference of the surgeon. In 55 (81%) of 68 partial pancreatectomies, a pancreaticojejunostomy was constructed by invagination of the pancreatic remnant into the jejunum, usually in an end-to-end fashion. Five additional patients (7%) had a mucosa-to-mucosa anastomosis between the pancreatic duct and jejunum. In eight patients (12%) the pancreatic duct was ligated and the pancreatic remnant oversewn without the formation of a pancreatic-enteric anastomosis.

Over the 18-year period, the mean operative time for all 88 patients was 8.4 ± 0.24 hours, the mean estimated

blood loss was 2519 ± 263 mL, and the mean intraoperative transfusion requirement was 4.9 ± 0.40 units (Table 2). Compared with the 20 patients managed by total pancreatectomy, mean operative time was significantly less for the 68 patients treated by a partial pancreatectomy (9.5 ± 0.52 hours vs. 8.1 ± 0.25 hours, $p < 0.05$). However, mean intraoperative blood loss (3014 ± 464 mL vs. 2286 ± 312 mL, $p = 0.10$) and mean intraoperative transfusion requirement (5.9 ± 0.65 units vs. 4.7 ± 0.48 units, $p = 0.11$) were not significantly different between the two groups.

Mean tumor diameter was 3.4 ± 0.15 cm for the 50 patients with adenocarcinoma of the head of the pancreas and 2.1 ± 0.20 cm for the 38 patients with adenocarcinoma of the ampulla, distal bile duct, and duodenum. Pathologic examination of the resected specimen revealed positive regional lymph nodes in 37 of the 50 patients (74%) with adenocarcinoma of the pancreas and 19 of the 38 patients (50%) with adenocarcinoma of the ampulla, distal bile duct, and duodenum (Table 3).

When one compares the two periods, there were a number of differences in the operative management of the two groups of patients (Table 2). Between 1969 and 1980, total pancreatectomy was performed in 16 of 41 patients (39%), whereas only four of 47 patients (9%) had total pancreatectomy during the recent period ($p < 0.01$). A pyloric-preserving Whipple procedure was performed in 14 of 47 patients (30%) operated on between 1981 and 1986, whereas no pyloric-preserving procedures were done during the earlier period. A truncal vagotomy was performed in 31 of 41 patients (76%) operated on between 1969 and 1980, whereas only 12 of 47 patients (26%) had a vagotomy during the recent period ($p < 0.01$).

Between 1981 and 1986, mean operative time (7.8 ± 0.31 hours vs. 9.0 ± 0.34 hours, $p < 0.05$), mean estimated blood loss (1694 ± 281 mL vs. 3271 ± 440 mL, $p < 0.01$), and mean intraoperative blood replace-

TABLE 3. Results of Pathologic Examination of Patients Undergoing Pancreaticoduodenectomy*

	Adenocarcinoma of the Pancreas			p
	1969–1986 (N = 50)	1969–1980 (N = 26)	1981–1986 (N = 24)	
Mean tumor diameter (cm)	3.4 ± 0.15	3.5 ± 0.17	3.2 ± 0.27	NS
Positive lymph nodes	37 (74)	19 (73)	18 (75)	NS
Lymph node status				
0 nodes	13 (26)	7 (27)	6 (25)	NS
1–2 nodes	20 (40)	8 (31)	12 (50)	NS
>2 nodes	17 (34)	11 (42)	6 (25)	NS
	Ampullary Distal Bile Duct and Duodenal Carcinoma			p
	1969–1986 (N = 38)	1969–1980 (N = 15)	1981–1986 (N = 23)	
Mean tumor diameter (cm)	2.1 ± 0.20	1.9 ± 0.22	2.2 ± 0.28	NS
Positive lymph nodes	19 (50)	6 (40)	13 (57)	NS
Lymph node status				
0 nodes	19 (50)	9 (60)	10 (43)	NS
1–2 nodes	9 (24)	3 (20)	6 (26)	NS
>2 nodes	10 (26)	3 (20)	7 (30)	NS

* Numbers in parentheses represent percentages.

ment (3.6 ± 0.37 units vs. 6.3 ± 0.65 units, $p < 0.01$) were all significantly less than in the earlier period. In addition, during the recent period, there were more Whipple resections performed each year (7.8 vs. 3.4) and by a fewer number of surgeons (3.4 operations/surgeon vs. 1.9 operations/surgeon). Comparison of the pathologic specimens for the two periods, however, revealed no significant differences between the two groups in terms of tumor size or stage of the disease (Table 3).

Clinical Course

A major postoperative complication developed in 41 of 88 patients for an overall morbidity rate of 47%

(Table 4). A major complication occurred in 22 of 50 patients (44%) with adenocarcinoma of the head of the pancreas and in 19 of 38 patients (50%) with adenocarcinoma of the ampulla, distal bile duct, and duodenum. Among the 68 patients in whom a partial pancreatic resection was performed, a significant complication developed in 35 (51%), whereas a major postoperative complication occurred in seven of 20 patients (35%) managed by total pancreatectomy ($p > 0.05$). A significant postoperative complication developed in 36 of 74 patients (49%) in whom a partial gastric resection was performed and in five of 14 patients (36%) who had a pyloric-sparing Whipple procedure.

TABLE 4. Morbidity and Mortality of Patients Undergoing Pancreaticoduodenectomy*

	1969–1986 (N = 88)	1969–1980 (N = 41)	1981–1986 (N = 47)	p
Overall morbidity	41 (47)	24 (59)	17 (36)	<0.05
Individual complications				
Pancreatic fistula	12 (18)	6 (22)	6 (14)	NS
Sepsis	17 (19)	12 (29)	5 (11)	<0.05
Wound infection	12 (14)	6 (15)	6 (13)	NS
Intra-abdominal abscess	9 (10)	7 (17)	2 (4)	<0.05
Upper gastrointestinal bleeding	9 (10)	6 (15)	3 (6)	NS
Intra-abdominal hemorrhage	6 (7)	5 (12)	1 (2)	NS
Gastric outlet obstruction	25 (28)	10 (24)	15 (32)	NS
Choledochojejunal fistula	6 (7)	3 (7)	3 (6)	NS
Pulmonary embolus	3 (3)	3 (7)	0	NS
Pulmonary edema	6 (7)	4 (10)	2 (4)	NS
Pneumonia	6 (7)	4 (10)	2 (4)	NS
Urinary tract infection	8 (9)	6 (15)	2 (4)	NS
Stroke	2 (2)	2 (5)	0	NS
Renal failure	9	6 (15)	3 (6)	NS
Overall mortality	11 (12.5)	10 (24)	1 (2)	<0.05

* Numbers in parentheses represent percentages.

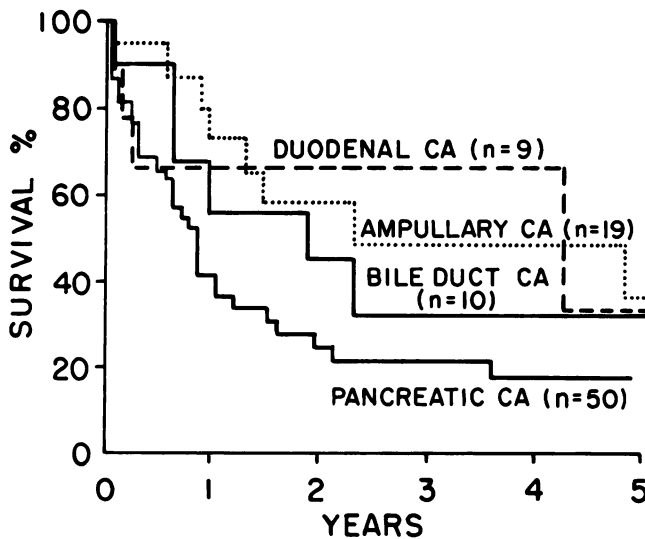


FIG. 1. Actuarial 5-year survival after Whipple resection for patients with adenocarcinoma of the pancreas, ampulla of Vater, distal bile duct, and duodenum.

A pancreatic fistula, defined as the persistent drainage of 50 mL or more of amylase-rich fluid per day for more than 2 weeks, developed in 12 of 68 patients (18%) who had a partial pancreatectomy. Eleven of these 12 fistulas closed spontaneously. One patient required reoperation 2 years after pancreaticoduodenectomy for a persistent fistula. Sepsis occurred in 17 of 88 patients (19%). In eight patients, the septic episode was related to the presence of an intra-abdominal abscess. Septic thrombophlebitis or central line sepsis occurred in five patients, urosepsis occurred in three patients, and cholangitis occurred in one patient. Wound infection occurred in 12 of 88 patients (14%).

An intra-abdominal abscess developed in nine of 88 patients (10%), requiring reoperation or percutaneous drainage. An intra-abdominal abscess occurred in six of 68 patients (9%) in whom a partial pancreatic resection was performed and in three of 20 patients (15%) managed by total pancreatectomy ($p > 0.05$). The presence of an underlying pancreatic fistula did not correlate with the subsequent development of either a wound infection or an intra-abdominal abscess.

Upper gastrointestinal bleeding developed in nine of 88 patients (10%). Bleeding occurred in five of 43 patients (12%) in whom a vagotomy was performed and in four of 45 patients (9%) managed without a vagotomy. One of 14 patients (7%) who had a pyloric-preserving Whipple procedure and eight of 74 patients (11%) in whom a partial gastric resection was performed had upper gastrointestinal bleeding ($p > 0.05$). Postoperative intra-abdominal hemorrhage requiring reoperation occurred in six of 88 patients (7%). Six patients required emergency re-exploration: one on the day of the initial

operation, four on the first postoperative day, and one on the second postoperative day.

Temporary gastric outlet obstruction requiring nasogastric decompression for greater than 10 days occurred in 25 of 88 patients (28%). Delayed gastric emptying occurred in 12 of 43 patients (28%) in whom a truncal vagotomy was performed and in 13 of 45 patients (29%) managed without a vagotomy. Four of 14 patients (29%) who had a pyloric-preserving Whipple procedure and 21 of 74 patients (28%) in whom a partial gastric resection was performed had delayed gastric emptying.

In comparing the two periods, a significant decrease in the overall operative morbidity was observed during the more recent time period (Table 4). The overall morbidity rate was 36% among the patients operated on between 1981 and 1986 and 59% for those operated on between 1969 and 1980 ($p < 0.05$). During the recent period, there was a decreased incidence of many individual complications. However, analysis of the individual complications revealed a statistically significant decrease only with the complications of intra-abdominal abscess and sepsis.

There were 11 postoperative deaths among the 88 patients for an overall hospital mortality rate of 12.5% (Table 4). Four (36%) of the 11 patients died of sepsis and multisystem failure on the 26th, 49th, 60th, and 87th postoperative days. None of these deaths was due to a pancreatic fistula. Two deaths were associated with massive postoperative intra-abdominal hemorrhage requiring re-exploration for control of the bleeding source. Both patients died on the 3rd postoperative day of renal failure and respiratory insufficiency. Two patients died of pneumonia and respiratory failure on the 31st and 48th postoperative days. Two additional patients died of a sudden cardiac arrest on the 7th and 33rd postoperative days. Both of these deaths occurred in patients whose postoperative courses were otherwise unremarkable. The remaining patient died of acidosis and refractory hypotension on the 9th postoperative day. Postmortem examination revealed an infarcted right lobe of the liver, presumably as a consequence of ligation of an aberrant right hepatic artery arising from the superior mesenteric artery. During the recent period, a severe reduction in operative mortality has been observed. Ten deaths occurred during 1969–1980, whereas only one patient died in the recent period for hospital mortality rates of 24% and 2%, respectively ($p < 0.05$).

During the entire 18-year period, the actuarial 5-year survival rate was 18% for the 50 patients with adenocarcinoma of the pancreas (Fig. 1). The actuarial 5-year survival rate was 48% for the 13 patients with negative lymph nodes and 1% for the 37 patients with one or more positive lymph nodes ($p < 0.05$) (Fig. 2). There were no statistically significant differences in the sur-

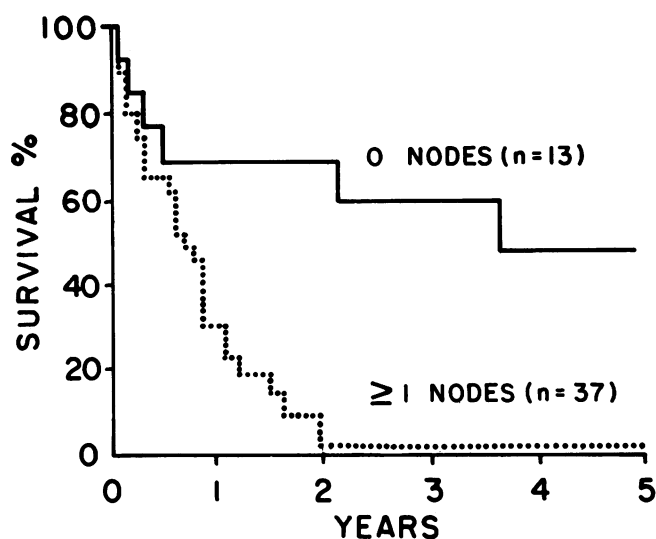


FIG. 2. Actuarial 5-year survival for those patients with adenocarcinoma of the pancreas with and without positive lymph node involvement.

vival curves between the 34 patients with pancreatic cancer managed by partial pancreatectomy and the 16 patients with pancreatic cancer in whom a total pancreatectomy was performed (Fig. 3). The actuarial 5-year survival rate was 36% for patients with ampullary cancer, 34% for patients with distal bile duct cancer, and 33% for patients with cancer of the duodenum (Fig. 1). Among the 38 patients with nonpancreatic periampullary cancer, the 5-year actuarial survival rate was 23% for the 18 patients with positive lymph nodes and 40% for the 18 patients with no involved lymph nodes ($p = 0.29$).

In comparing the two periods, there were no significant differences in the 5-year survival rates for the 26 patients with adenocarcinoma of the pancreas operated on between 1969 and 1980 and for the 24 patients with pancreatic cancer operated on during the recent period (Fig. 4). Likewise, the 5-year survival rate was similar for the 15 patients with nonpancreatic periampullary cancer operated on during 1969–1980 and for the 23 patients operated on during the recent period.

Thirty-two of 50 patients with adenocarcinoma of the pancreas were operated on 5 or more years ago. Among these 32 patients, six have survived 5 years or longer. Of these six patients, four are alive at 60, 66, 72, and 132 months, respectively. One patient died 76 months after the Whipple resection of metastatic adenocarcinoma of the pancreas, whereas the remaining patient died at 66 months of unknown causes. In comparing the six long-term survivors with the 26 nonsurvivors, there was a trend toward a smaller tumor size among those surviving 5 years or more (2.7 cm vs. 3.2 cm, $p = 0.18$). In addition, positive lymph nodes were present in only

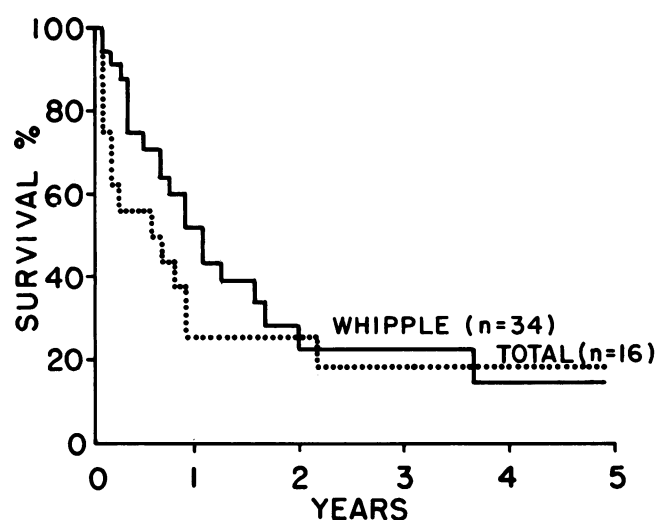


FIG. 3. Five-year actuarial survival for patients with adenocarcinoma of the pancreas managed either by total or partial pancreatectomy.

one of the six (17%) 5-year survivors, whereas 22 of the 26 (85%) nonsurvivors had positive lymph nodes ($p < 0.05$).

Discussion

Over the past decade, a marked decline in hospital morbidity and mortality has been observed for patients undergoing pancreaticoduodenectomy. During the 1960s and 1970s, many centers^{11–13} reported operative morbidity and mortality rates of 40–60% and 20–40%, respectively. However, a number of recent clinical re-

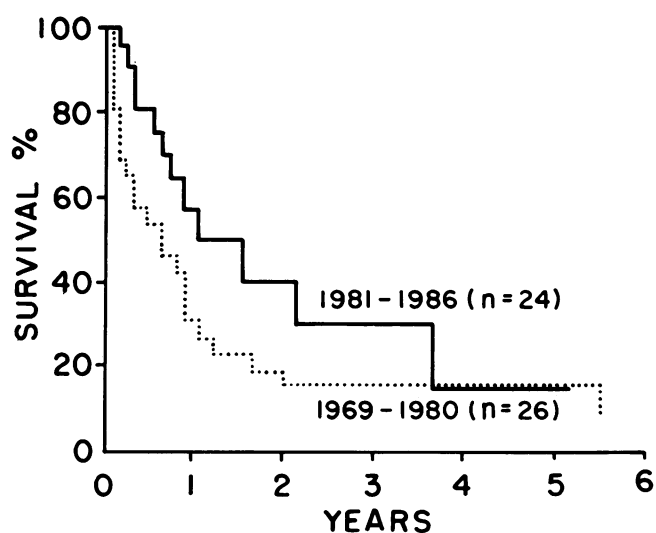


FIG. 4. Actuarial 5-year survival for patients with adenocarcinoma of the pancreas operated on between 1969 and 1980, and between 1981 and 1986. Survival at 5 years is similar for both groups of patients. The difference in survival during the earlier years is explained by the higher operative mortality during the earlier period.

ports⁷⁻⁹ have documented an operative morbidity rate in the range of 30% and a hospital mortality rate of approximately 5%. A similar decline in hospital morbidity and mortality was noted in the current study. Among the 41 patients operated on during 1969–1980, hospital morbidity and mortality rates were 59% and 24%, respectively. In contrast, among the 47 patients operated on during the recent period, the perioperative morbidity and mortality rates fell to 36% and 2%, respectively.

The decline in operative morbidity and mortality observed during the recent period cannot be explained on the basis of a more select patient population, earlier diagnosis, or extent of disease at the time of operation. Comparison between the two periods revealed no significant differences between the two groups of patients in terms of mean age, race or sex distribution, associated medical illness, or preoperative nutritional status. Likewise, mean duration of symptoms and mean serum bilirubin levels at the time of presentation were similar for both groups of patients. Moreover, the stage of disease as assessed by mean tumor diameter and lymph node status were nearly identical for the two groups of patients.

In comparing the two periods, the number of Whipple resections performed each year at this institution for carcinoma of the head of the pancreas, ampulla, distal bile duct, and duodenum has increased from 3.4 operations per year to 7.8 operations per year. During this same period, a greater number of Whipple resections were performed by fewer surgeons. Between 1969 and 1980, 41 Whipple resections were performed by 22 different surgeons (1.9 operations/surgeon). During the recent period, however, the 47 Whipple procedures were performed by 14 different surgeons (3.6 operations/surgeon) with 50% of the resections performed by one individual. In addition, there has been a considerable change in the type of operation performed during the recent period. Between 1981 and 1986, there were fewer total pancreatectomies (9% vs. 39%) and fewer vagotomies (26% vs. 76%) performed compared with the earlier period. In addition, a pyloric-sparing Whipple procedure was performed in 14 of 47 patients (30%) operated on during the recent period, whereas a partial gastric resection was performed in all 41 patients operated on between 1969 and 1980. The fact that more operations were performed by fewer surgeons, and that a lesser operation was performed during the recent period, probably account for the shorter operative time (7.8 hours vs. 9.0 hours), the decreased mean intraoperative blood loss (1694 mL vs. 3271 mL), and the decreased transfusion requirement (3.6 units vs. 6.3 units) between 1981 and 1986. These findings suggest that the recent decline in operative morbidity and mortality may be due to fewer

surgeons performing more Whipple resections in less time and with less blood loss.

Pancreatic fistula was a common complication in this series, and occurred in 12 of 68 patients (18%) in whom a partial pancreatic resection was performed. Fewer pancreatic fistulas developed during the recent period (14% vs. 22%), although this difference did not reach statistical significance. In contrast to other reports,^{14,15} there were no deaths that could be directly attributed to the development of a pancreatic fistula in the current series. Neither did the presence of a fistula correlate with the presence of an intra-abdominal abscess, sepsis, or a wound infection. In addition, only one of 12 patients with a pancreatic fistula required reoperation for closure of the fistula at a later time.

Temporary delayed gastric emptying was the most common complication in this series and occurred in 25 of 88 patients (28%). The incidence of delayed gastric emptying was similar among those patients in whom a vagotomy was performed and in those managed without a vagotomy (28% vs. 29%). The incidence was also similar in those patients in whom a pyloric-sparing Whipple procedure was performed compared with those managed by a partial gastric resection (29% vs. 28%).

The actuarial 5-year survival rate for the 38 patients with nonpancreatic periampullary cancer was 34%. Although the 5-year survival rate (40%) was greater for those patients without lymph node metastases compared with those with nodal involvement (28%), this did not reach statistical significance. The 5-year survival rate for nonpancreatic periampullary cancer in this series was similar to the 30–40% 5-year survival rate reported by others,^{15–17} but is less than the 58% 5-year survival rate reported by Grace and Associates⁸ and the 70% 5-year survival rate in the series reported by Braasch and co-workers.⁹ Surprisingly, the actuarial 5-year survival rate for the 50 patients in the current series with adenocarcinoma of the pancreas was 18%. Six of the 32 patients operated on 5 or more years ago have survived 5 years. Lymph node involvement was very important, with the 5-year actuarial survival rate being 48% in the absence of positive nodes and only 1% when lymph nodes were involved. There was also a trend toward improved survival with a smaller tumor mass. Both findings suggest that earlier diagnosis could have a great effect on overall survival for carcinoma of the pancreas. Of interest, however, is the finding that long-term survival is possible even in patients with positive lymph nodes. One of six long-term survivors with adenocarcinoma of the pancreas was found to have two positive lymph nodes in the resected specimen. This patient is currently alive 66 months after the Whipple resection. There was no difference in survival for those patients

managed by total pancreatectomy when compared with those managed by partial pancreatectomy. The improvement in survival seen in this series was present throughout both periods, and a report from this institution¹⁸ covering from 1959–1968, suggests that improved survival for pancreatic cancer was present then. To be certain that our six long-term survivors with pancreatic adenocarcinoma were not in fact patients with more favorable distal bile duct or ampullary lesions, all specimens were re-examined by a pathologist not involved in the original sign-out. All were confirmed as carcinoma of the head of the pancreas. A similar trend toward improved survival for patients with carcinoma of the head of the pancreas has also been noted by the GI Tumor Study group¹⁰ and by Braasch and associates.⁹ There is no obvious explanation for this observed improvement in survival for carcinoma of the head of the pancreas.

Acknowledgments

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References

1. Halsted WS. Contributions to the surgery of the bile passages, especially of the common bile duct. *Boston Med Surg J* 1899; 141:645–654.
2. Whipple AO, Parsons WB, Mullins CR. Treatment of carcinoma of the ampulla of Vater. *Ann Surg* 1935; 102:763–779.
3. Trimble IR, Parsons JW, Sherman CP. A one-stage operation for the cure of carcinoma of the ampulla of Vater and the head of the pancreas. *Surg Gynecol Obstet* 1941; 73:711–722.
4. Crile G Jr. The advantages of bypass operations over radical pancreatoduodenectomy in the treatment of pancreatic carcinoma. *Surg Gynecol Obstet* 1970; 130:1049–1053.
5. Crile G Jr, Isbister WH, Hawk WA. Carcinoma of the ampulla of Vater and terminal bile and pancreatic ducts. *Surg Gynecol Obstet* 1970; 131:1052–1054.
6. Shapiro TM. Adenocarcinoma of the pancreas: a statistical analysis of bypass vs Whipple resection in good risk patients. *Ann Surg* 1975; 182:715–721.
7. Trede M. The surgical treatment of pancreatic carcinoma. *Surgery* 1985; 97:28–35.
8. Grace PA, Pitt HA, Tompkins RK, et al. Decreased morbidity and mortality after pancreatoduodenectomy. *Am J Surg* 1986; 151:141–149.
9. Braasch JW, Deziel DJ, Rossi RL, et al. Pyloric and gastric preserving pancreatic resection: experience with 87 patients. *Ann Surg* 1986; 204:411–418.
10. Kalsner MH, Ellenberg SS. Pancreatic cancer. Adjuvant combined radiation and chemotherapy following curative resection. *Arch Surg* 1985; 120:899–903.
11. Gilsdorf RB, Spanos P. Factors influencing morbidity and mortality in pancreaticoduodenectomy. *Ann Surg* 1973; 177:332–337.
12. Morris PJ, Nardi GL. Pancreaticoduodenal cancer. *Arch Surg* 1966; 92:834–837.
13. Lansing PB, Blalock JB, Oschner JL. Pancreaticoduodenectomy: a retrospective review, 1949–1969. *Am Surg* 1972; 38:79–86.
14. Lerut JP, Gianello PR, Otte JB, et al. Pancreaticoduodenal resection. Surgical experience and evaluation of risk factors in 103 patients. *Ann Surg* 1984; 199:432–437.
15. Hertner FP, Cooperman AM, Ahlborn TN, et al. Surgical experience with pancreatic and periampullary cancer. *Ann Surg* 1982; 195:274–281.
16. Cohen JR, Kuchta N, Geller N, et al. Pancreaticoduodenectomy. A 40 year experience. *Ann Surg* 1982; 195:608–617.
17. Jones BA, Langer B, Taylor BR. Periampullary tumors: which ones should be resected? *Am J Surg* 1985; 149:46–52.
18. Baker RR, Pio Roda CL, Lee JM. Carcinoma of the head of the pancreas and periampullary region. *Johns Hopkins Med J* 1972; 132:212–221.